PATENT SPECIFICATION

677,941

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COMPLETE SPECIFICATION.

Improvements in and relating to dynamo-electric machines

We, THE BRITISH THOMSON-HOUSTON COMPANY LIMITED, a British Company having its registered office at Crown House, Aldwych, London, W.C.2, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to rotors for dynamo-electric machines, and more particularly to rotors for synchronous induction motors having permanent magnet excitation with means for preventing demagnetization of the permanent magnet due to alternating flux from the stator winding at speeds other than synchronous.

Conventional synchronous motors are normally provided with a rotor having a certain number of direct current excited poles, the pole faces of which are usually supplied with squirrel cage bars and end rings to effect self starting and to dampen hunting. In motors of fractional horsepower frame sizes, however, it is often physically inconvenient to provide salient direct current excited poles, and accordingly, such motors may be provided with permanent magnet excited rotors as shown for example in Specification No. 536661. Such motors include a stator member with a winding energized by alternating current and a rotor member having a permanent magnet surrounded by a laminated sleeve. Slots are provided in the outer surface of the sleeve in which squirrel cage bars are positioned, the bars being short-circuited by end rings forming a sort-circuited winding for self-starting.

At speeds other than synchronous, the alternating flux produced by the stator winding tends to demagnetize the permanent magnet. In addition, there is a further demagnetizing effect on the permanent magnet due to stator flux changes caused by sudden variations in the load or energizing voltage. The short-circuited squirrel cage winding has some dampening effect on these demagnetizing forces which may be sufficient to protect the permanent magnet. However, it has been found desirable to supplement and increase the protective action of the squirrel cage by providing additional means for dampening the alternating flux produced by the stator winding at speeds other than synchronous or stator flux changes caused by variations in the external magnetic circuit.

An object of this invention is to provide an improved permanent magnet excited rotor for synchronous induction motors with means for preventing demagnetization of the permanent magnet, so that the most efficient use is made of the permanent magnet material.

In accordance with this invention, a permanent magnet excited rotor for a dynamo electric machine having a conventional stator member comprises a permanent magnet polarised radially to form polar areas at its outer surface and apertured to receive a shaft, a shaft arranged in the aperture, a laminated sleeve member arranged around the permanent magnet and having a plurality of slots formed in its outer surface, a plurality of squirrel cage winding conductors respectively positioned in the slots and means short-circuiting the conductors, bars of conductive material respectively abutting the sides of the permanent magnet intermediate the polar areas, and a pair of end plates of conductive material respectively connecting the bars to form a closed loop of conductive material around the permanent magnet.

By virtue of the squirrel cage winding, a motor provided with this improved rotor will start as an induction motor; however, the permanent magnet core will cause it to pull into step and run as a synchronous motor. The loop of conductive material around the magnet intermediate the polar areas dampens the alternating flux produced by the stator winding when the rotor is not running in synchronism and the stator flux changes due to variations in the external magnetic circuit,

thus, preventing demagnetization of the magnet.

The invention will be better understood from the following description referring to the accompanying drawings in which, Fig. 1 is a perspective view illustrating the improved permanent magnet excited rotor of this invention, Fig. 2 is a cross-sectional view showing the rotor of Fig. 1 positioned in a stator member; Fig. 3 is an exploded view in perspective illustrating the assembly of the improved rotor of Fig. 1; and Fig. 4 is a cross-sectional view illustrating the application of the improved permanent magnet rotor construction of this invention to a 4 pole permanent magnet.

Referring now to Figs. 1, 2, and 3, there is shown a rotor member 1 having a permanent magnet 2, preferably formed of a permanent magnet alloy of iron, nickel, cobalt, copper, titanium and aluminium. The permanent magnet 2 is mounted on a shaft 3 formed of magnetic material, such as steel, and has two diametrically opposite arcuate longitudinal surfaces 4 and two parallel substantially flat longitudinal surfaces 5, the flat surfaces 5 being formed along a chord of the circle of the arcuate surfaces 4, as shown in Fig. 2. The permanent magnet 2 is polarized radially to form polar areas at the surfaces 4, as shown by the designations N, S in Fig. 2. A pair of bars 6 formed of conductive material, such as copper or aluminium, are respectively positioned abutting the sides 5 of the permanent magnet and are provided with arcuate outer surfaces 7. Thus, the outer surfaces 7 of the conductive bars 6 form with the curved surfaces 4 of the permanent magnet 2 a cylindrical core structure. A pair of end plates 8 formed of conductive material are provided having a cross-sectional configuration substantially identical to the permanent magnet 2. The end plates 8 are press fitted over the shaft member 3, respectively abutting either end of the permanent magnet 2, and also abut the ends of the conductive bars 6, which project beyond the ends of the magnet 2. End plates 8 may also be soldered to bars 6. A cylindrical laminated sleeve member 9, formed of a plurality of relatively thin laminations 10 of magnetic material, is pressed over the cylindrical core structure comprising the permanent magnet 2, the side bars 6 and the end plates 8. The sleeve member 9 is provided with a plurality of longitudinal slots 11 in its outer surface and a plurality of squirrel cage bars 12 of conductive material, such as aluminium, are positioned therein. A pair of conductive end rings 13 are provided to connect the squirrel cage bars 12 to form a short-circuited squirrel cage winding.

When the rotor 1, as described above, is positioned in a stator member 14 of any conventional type, which may be provided with a yoke section 15 and a plurality of winding slots 16 in which appropriate windings (not shown) adapted to be energized by alternating current are positioned, the motor will be self-starting as an induction motor by virtue of the squirrel cage winding and will pull into step and run at synchronism as a synchronous motor on the uni-directional excitation provided by the permanent magnet 2.

It can be readily seen that the alternating flux produced by the stator windings will traverse the permanent magnet 2 and at speeds other than synchronous, will tend to demagnetize the magnet. In addition, stator flux changes caused by variations in load or line voltage tend to produce a demagnetizing effect on the magnet. The conductive bars 6 and the end plates 8 form a loop of conductive material around the permanent magnet 2 intermediate the polar areas and serve to dampen the demagnetizing effect of the alternating flux and changes in the external magnetic circuit. Furthermore, with this construction, the permanent magnet 2 can be formed so as to have a slide fit over the shaft 3, the torque drive from the shaft or to the shaft being transmitted through the bar and damping assembly 6, 8. It has been found impractical to press brittle permanent magnet material over a shaft since it is subject to cracking. However, it is permissible to press the rotor assembly comprising the permanent magnet 2 and the damper assembly 6, 8 into the sleeve member 9.

In the construction of a rotor member in accordance with Figs. 1, 2, and 3, it has been found desirable to fabricate the laminated sleeve member 9 so that the section 17 under the squirrel cage bars 12 is as radially thin as possible in order to produce a high initial flux density under the bars to secure synchronous rather than induction motor operation. Furthermore, the provision of the thin section 17 permits the use of the largest possible diameter permanent magnet 2. The width of the arcuate polar surface portions 4 circumferentially is preferably made to subtend approximately two-thirds of the pole pitch on the inside of the laminated sleeve member 9. A flux density of 95,000 to 125,000 lines per square inch in the section 17 produced by a flux density in the magnet of approximately 60,000 lines per square inch, following magnetization of the rotor but prior to its assembly in the stator, was found to be desirable. It was found that an initial density in the section 17 less than 95,000 lines per square inch caused the motor power to decrease rapidly while a density over 125,000 lines per square inch caused the pull-in torque to fall off, produced no further gain in pull-out torque, and the power factor and efficiency decreased. Furthermore, if the section 17 underneath

the squirrel cage bars 12 was comparatively wide, a considerable portion of the permanent magnet flux would be short-circuited. However, the provision of a thin section 17 provides a path of high reluctance around the permanet magnet 2 so that a substantial part of the permanent magnet flux is diverted to the stator at sychronism, as described in the specification of our Application No. 13501/50 (Serial No. 677,942).

The presence of the shaft 3 of magnetic material through the centre of the permanent magnet 2 allows the main magnet flux to pass directly through the centre of the shaft which has the effect of increasing the central magnet area by the projected shaft area. In addition, a permanent magnet of the configuration described above with the flat sides 5 is somewhat more desirable than a completely cylindrical magnet because of the reduced flux leakage from the high density interpolar ring section 17.

Referring now to Fig. 4 in which like elements are indicated by like reference numerals, there is shown a four pole permanent magnet 18, preferably formed of a permanent magnet alloy such as nickel, cobalt, copper, titanium, and aluminium. The permanent magnet 18 is mounted on a shaft 3 formed of magnetic material, such as steel, and is polarized radially to form four polar areas as shown. The interpolar areas 19 are cored out to effect saving of magnetic material and to accommodate bars 20. The bars 20 are formed of conductive material, such as copper, or aluminium and are provided with arcuate outer surfaces 21 which form with the curved polar faces of the permanent magnet 18, a cylindrical core structure. A pair of end plates (not shown) formed of conductive material are provided having a cross-sectional configuration substantially identical to the permanent magnet 18. These end plates are press fitted over the shaft 3, respectively abutting either end of the permanent magnet 18, and serve to connect the ends of the conductive bars 20, in the manner shown in Fig 3. A cylindrical laminated sleeve member 9 formed of a plurality of relatively thin laminations 10 of magnetic material is pressed over the cylindrical core structure comprising the permanent magnet 18, the conductive bars 20 and the end plates. The sleeve member 9 is provided with a plurality of longitudinal slots 11 in its outer surface and a plurality of squirrel cage bars 12 of conductive material, such as aluminium, are positioned therein. A pair of conductive end rings (not shown) are provided to connect the squirrel cage bars 12 to form a complete short-circuited squirrel cage winding.

It will be readily apparent that the conductive bars 20 and their associated end plates may be separate elements which are secured together to form a unitary structure, as by soldering, or the conductive bars 20 and end plates may be cast in place as an integral unit, either prior to assembly of the permanent magnet 18 into the laminated sleeve member 9 or at the time squirrel cage bars 12 and end rings 13 are cast. It will also be seen that the construction is applicable to multipolar rotors having more than two pairs of poles. It will also be understood that the improved rotor construction of this invention may be utilised in a generator since the permanent magnet is protected against the demagnetizing effect of sudden changes in load by the dampening action of the squirrel cage winding and the conductive loop.

It will now be readily apparent that this invention provides an improved permanent magnet excited rotor for dynamo-electric machines wherein the alternating flux produced by the stator winding and the effect of changes in the external magnetic circuit are dampened to prevent demagnetization of the permanent magnet.

What we claim is:—

1. A rotor for a dynamo-electric machine (having a stator member) comprising a permanent magnet polarized radially to form polar areas at its outer surface and apertured to receive a shaft, a shaft arranged in the aperture, a laminated sleeve member arranged around the permanent magnet and having a plurality of slots formed in its outer surface, a plurality of squirrel cage winding conductors respectively positioned in the slots and means short-circuiting the conductors, bars of conductive material respectively abutting the sides of the permanent magnet intermediate the polar areas, and a pair of end plates of conductive material respectively connecting the bars to form a closed loop of conductive material around the permanent magnet for preventing demagnetization of the magnet due to alternating flux variations in the stator.

2. A rotor member as claimed in Claim 1 comprising a permanent magnet having two diametrically opposite arcuate longitudinal surfaces, the permanent magnet being polarized radially to form polar areas at the arcuate surfaces and having two parallel substantially flat longitudinal sides intermediate the polarized surfaces, each of the flat sides being formed along a chord of the circle of the arcuate surfaces, a pair of bars of conductive material respectively abutting the flat surfaces and having curved outer surfaces forming with the permanent magnet a cylindrical structure, and a pair of end plates of conductive material respectively connecting the ends of the bars.

3. A rotor member as claimed in Claim 1, comprising a permanent magnet polarized radially to form a plurality of pairs of polar

areas at its outer surface with the interpolar areas being cored out, bars of conductive material respectively positioned in the cored out interpolar areas and having curved outer surfaces forming with the permanent magnet a cylindrical structure, and a pair of end plates of conductive material respectively connecting the ends of the bars.

4. A rotor member as claimed in Claim 1, 2 or 3 the end plates being secured to the shaft for transmitting torque to or from the shaft.

5. A rotor member for a dynamo-electric machine constructed substantially as hereinbefore described and shown in Figs. 1-3, or 4, of the accompanying drawings.

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677,941 COMPLETE SPECIFICATION

I SHEET

This drawing is a reproduction of the Original on a reduced scale.

FIG.1.

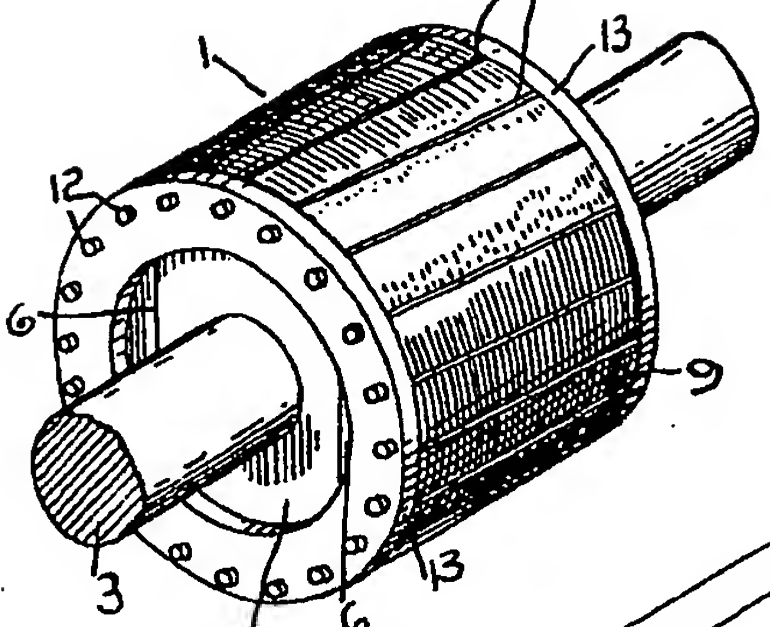

FIG.3.

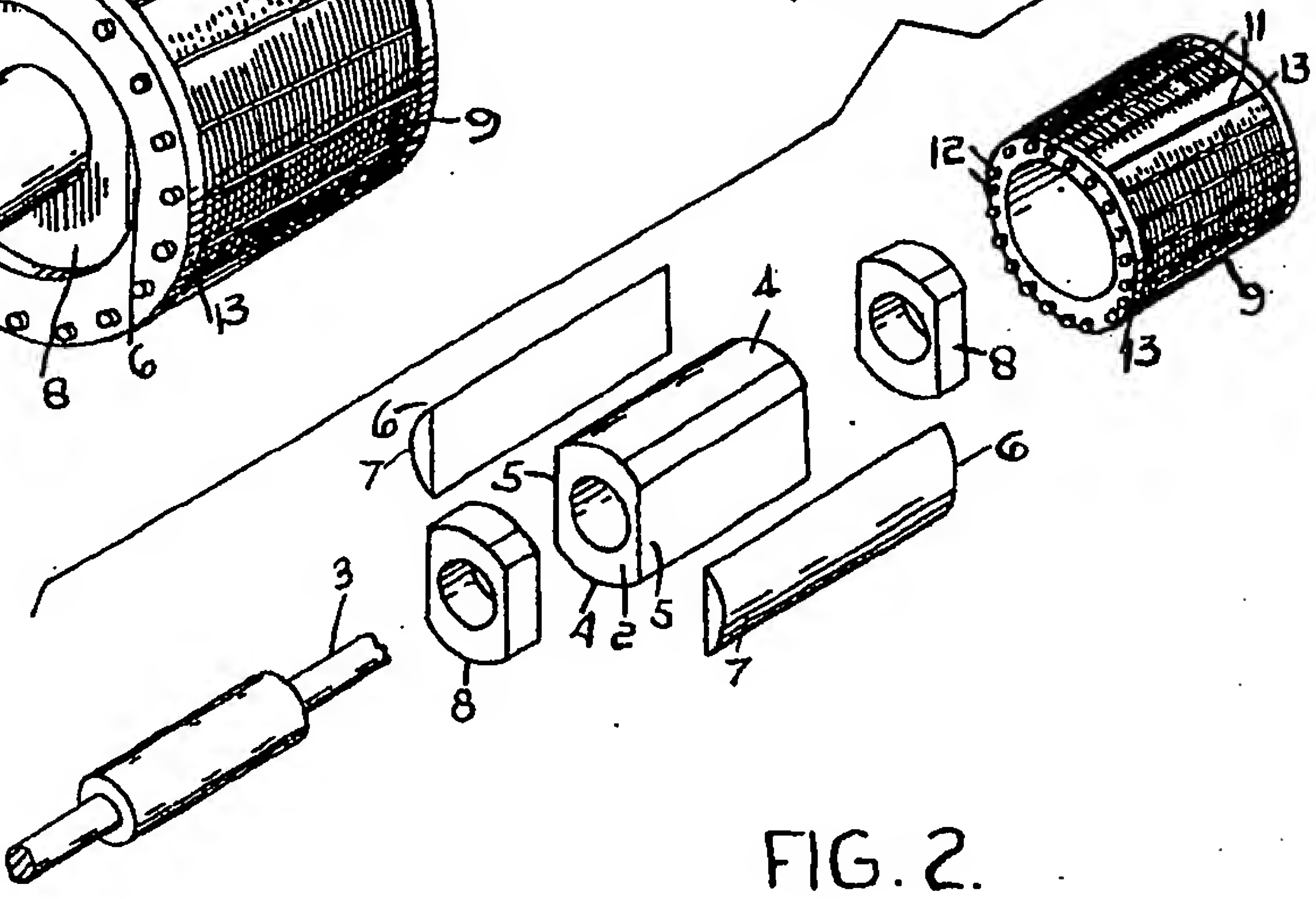

FIG.4.

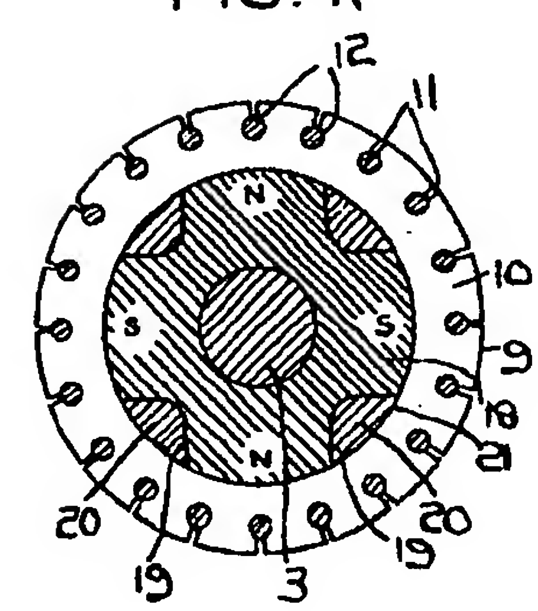

FIG.2.